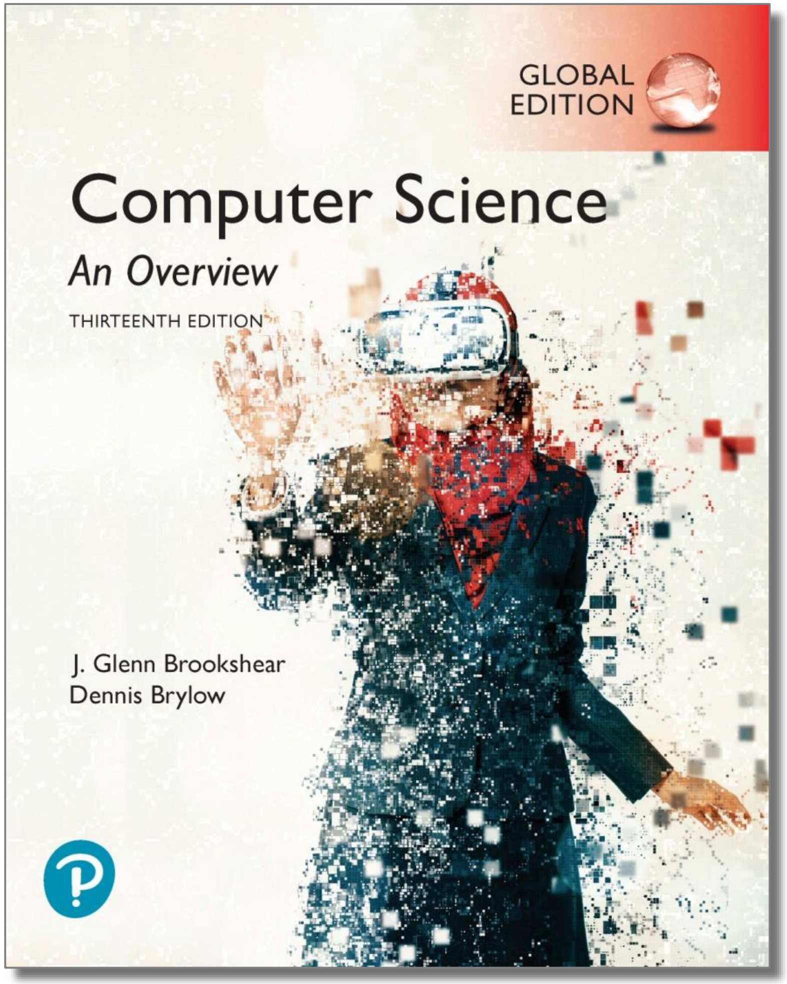
Computer Science An Overview

13th Edition, Global Edition



Chapter 0

Introduction

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Chapter 0: Introduction

- 0.1 The Role of Algorithms
- 0.2 The History of Computing
- 0.3 An Outline of Our Study
- 0.4 The Overarching Themes of Computer Science
  - Algorithms
  - Abstraction
  - Creativity
  - Data
  - Programming
  - Internet
  - Impact

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0.1 The Role of Algorithms

- **Algorithm:** A set of steps that defines how a task is performed
- **Program:** A representation of an algorithm
- **Programming:** The process of developing a program
- **Software:** Programs and the algorithms they represent
- **Hardware:** The machinery

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Figure 0.1
An algorithm for a magic trick

Effect: The performer places some cards from a normal deck of playing cards face down on a table and mixes them thoroughly while spreading them out on the table. Then, as the audience requests either red or black cards, the performer turns over cards of the requested color.

Secret and Patter:

Step 1. From a normal deck of cards, select ten red cards and ten black cards. Deal these cards face up in two piles on the table according to color.

Step 2. Announce that you have selected some red cards and some black cards.

Step 3. Pick up the red cards. Under the pretense of aligning them into a small deck, hold them face down in your left hand and, with the thumb and first finger of your right hand, pull back on each end of the deck so that each card is given a slightly *backward* curve. Then place the deck of red cards face down on the table as you say, "Here are the red cards in this stack."

Step 4. Pick up the black cards. In a manner similar to that in step 3, give these cards a slight *forward* curve. Then return these cards to the table in a face-down deck as you say, "And here are the black cards in this stack."

Step 5. Immediately after returning the black cards to the table, use both hands to mix the red and black cards (still face down) as you spread them out on the tabletop. Explain that you are thoroughly mixing the cards.

Step 6. As long as there are face-down cards on the table, repeatedly execute the following steps:

6.1. Ask the audience to request either a red or a black card.

6.2. If the color requested is red and there is a face-down card with a concave appearance, turn over such a card while saying, "Here is a red card."

6.3. If the color requested is black and there is a face-down card with a convex appearance, turn over such a card while saying, "Here is a black card."

6.4. Otherwise, state that there are no more cards of the requested color and turn over the remaining cards to prove your claim.

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Figure 0.2
The Euclidean algorithm for finding the greatest common divisor of two positive integers

Description: This algorithm assumes that its input consists of two positive integers and proceeds to compute the greatest common divisor of these two values.

Procedure:

Step 1. Assign M and N the value of the larger and smaller of the two input values, respectively.

Step 2. Divide M by N, and call the remainder R.

Step 3. If R is not 0, then assign M the value of N, assign N the value of R, and return to step 2; otherwise, the greatest common divisor is the value currently assigned to N.

Step 1:

- M = 15, N = 6

Step 2:

- M / N
- 15 / 6 = 2, R = 3

Step 3:

- R <> 0
- M = 6, N = 3

Step 2:

- M / N
- 6 / 3 = 2, R = 0

Step 3

- R = 0

Greatest common divisor: N = 3

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History of Algorithms

- The study of algorithms was originally a subject in mathematics.
- Early examples of algorithms
  - Long division algorithm
  - Euclidean Algorithm
- **Gödel's Incompleteness Theorem**: Some problems cannot be solved by algorithms.

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0.2 The History of Computing

- Early computing devices
  - Abacus: positions of beads represent numbers
  - Gear-based machines (1600s-1800s)
    - Positions of gears represent numbers
    - Blaise Pascal, Wilhelm Leibniz, Charles Babbage

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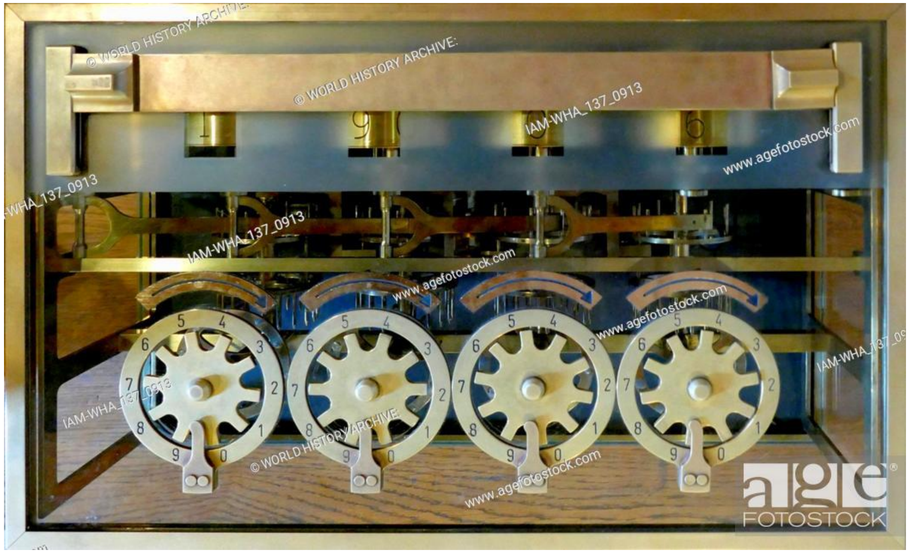
Figure 0.3
Chinese Wooden Abacus

Gear-based machines



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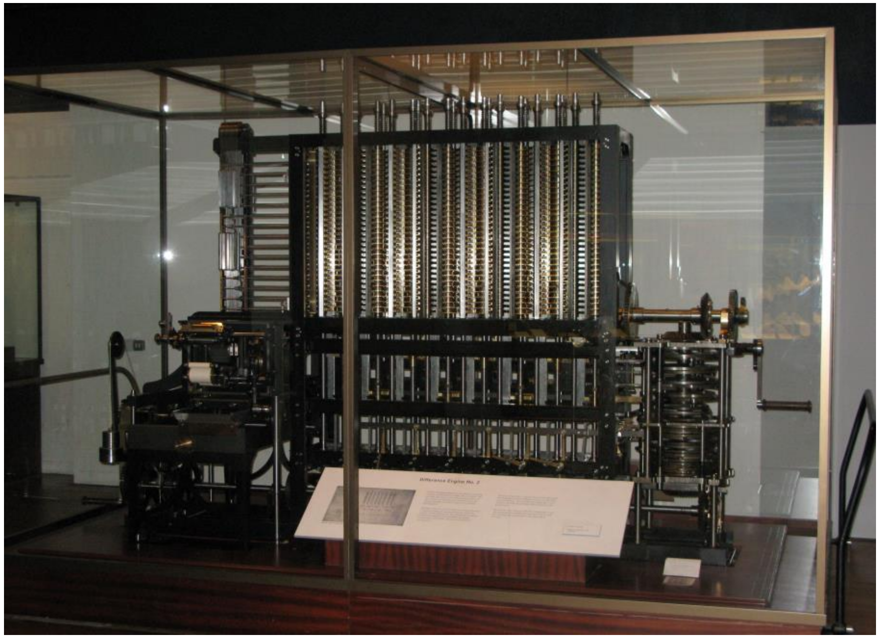
Charles Babbage



25000 parts, 13600 kg, 4 bits micro programmable CPU.

Babbage is considered by some to be “father of the computer” 1791~1871

Babbage is credited with inventing the first mechanical computer, the Difference Engine, that eventually led to more complex electronic designs, though all the essential ideas of modern computers are to be found in Babbage's Analytical Engine

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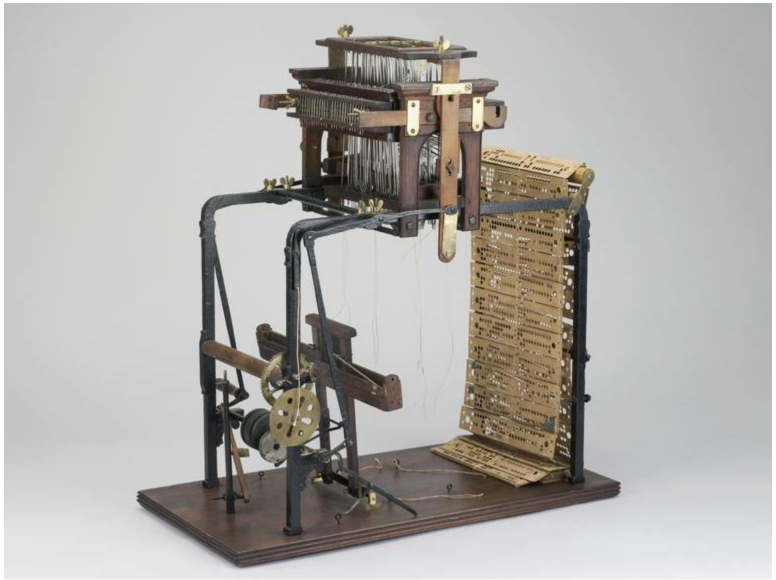
Early Data Storage

- Punched cards
  - First used in Jacquard Loom (1801) to store patterns for weaving cloth
  - Storage of programs in Babbage's Analytical Engine
  - Popular through the 1970's
- Gear positions



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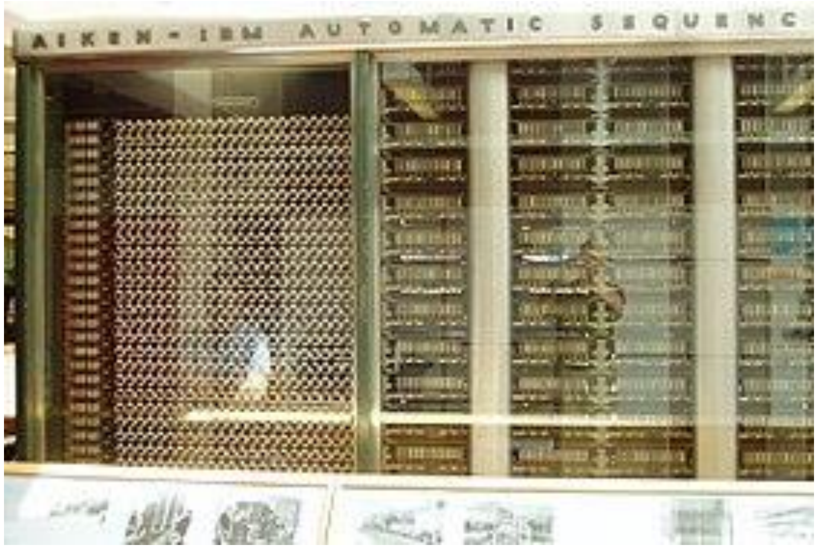
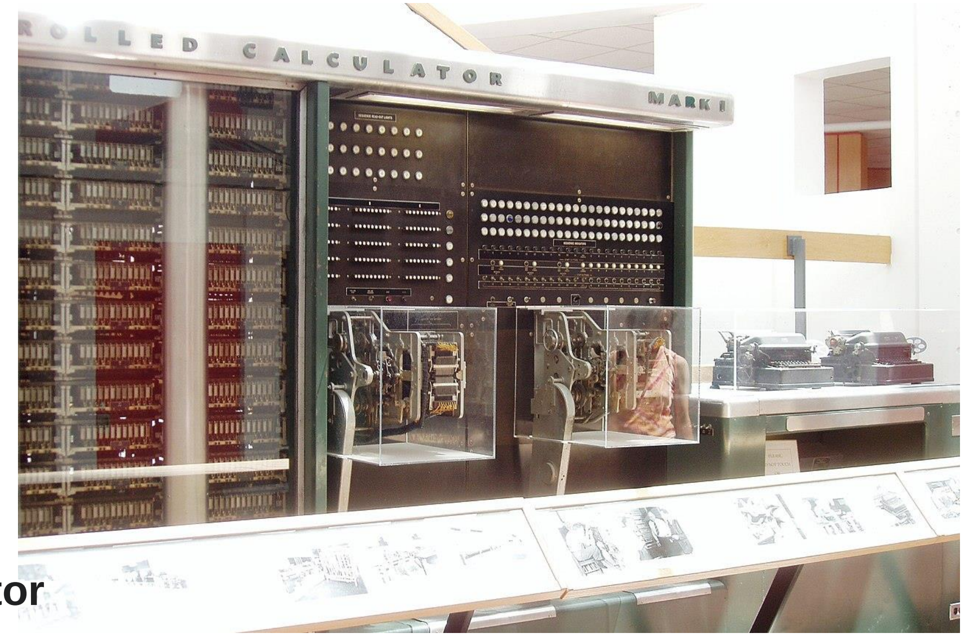
Early Computers

- Based on mechanical relays
  - 1940: Stibitz at Bell Laboratories
  - 1944: Mark I: Howard Aiken and IBM at Harvard





Automatic Sequence Controlled Calculator (ASCC)

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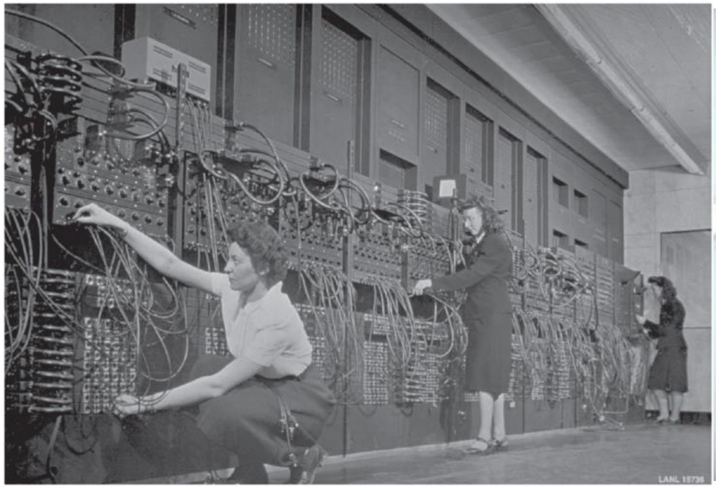
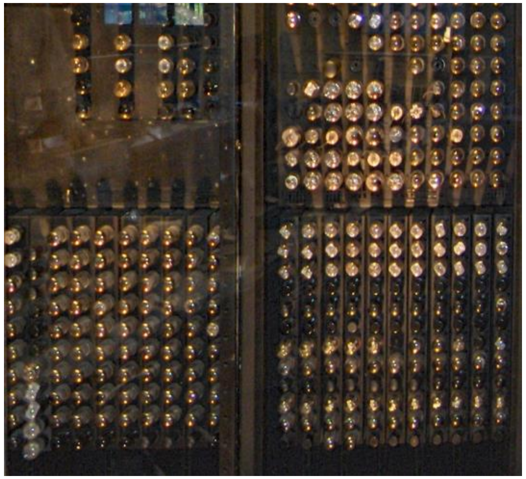
Early Computers

- Based on vacuum tubes
  - 1937-1941: Atanasoff-Berry at Iowa State
  - 1940s: Colossus: secret German code-breaker
  - 1940s: ENIAC: Mauchly & Eckert at U. of Pennsylvania.

(Electronic Numerical Integrator And Computer)





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Early Computers

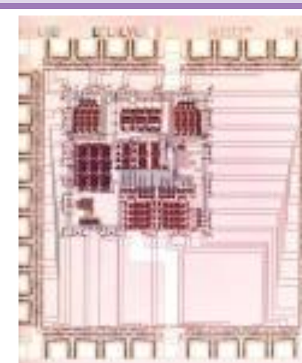
表1-1：第一代電腦到第四代電腦

項目代別	年　　代	電子元件	電子元件的大小	速度比較
第 一 代	1946～1959	真空管	大姆指	毫秒（10^{-3}秒）
第 二 代	1959～1964	電晶體	鉛筆的橡皮頭	微秒（10^{-6}秒）
第 三 代	1964～1971	積體電路	0.5mm 鉛筆心	10 毫微秒（10^{-8}秒）
第 四 代	1971 年以後	超大型積體電路	比針尖小	毫微秒（10^{-9}秒）

Vacuum tubes
(真空管)

transistor
(電晶體)

IC (Integrated Circuit; 積體電路)



VLSI

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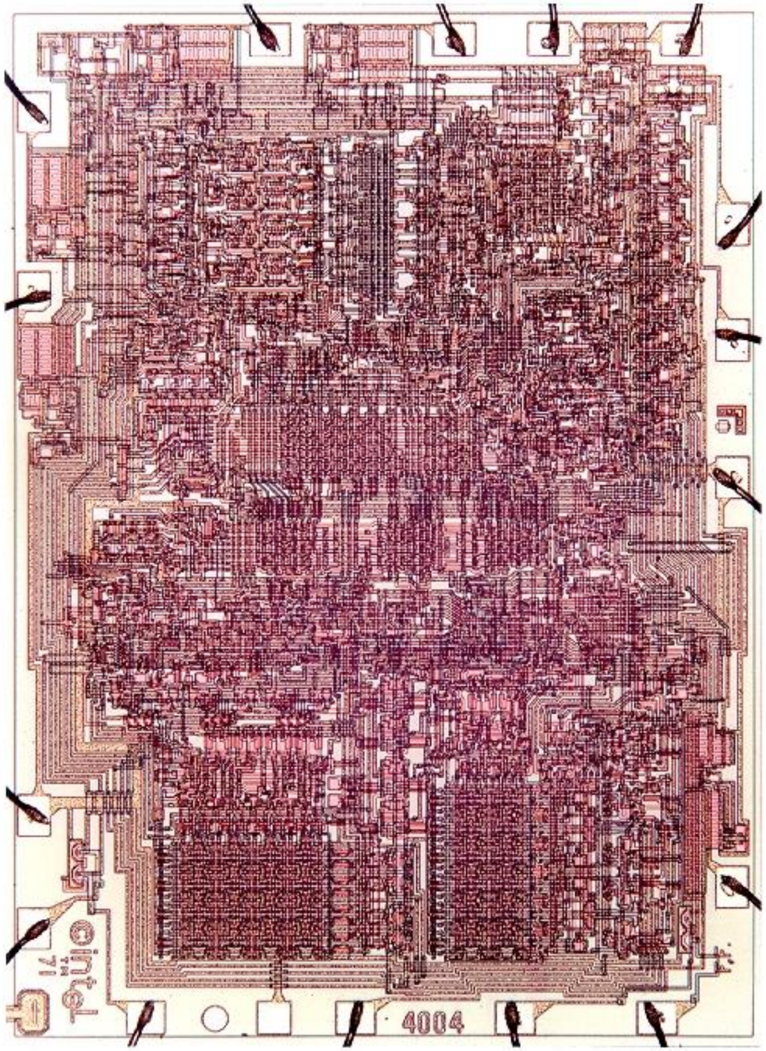
Early Computers

- Intel 4004 (1971)



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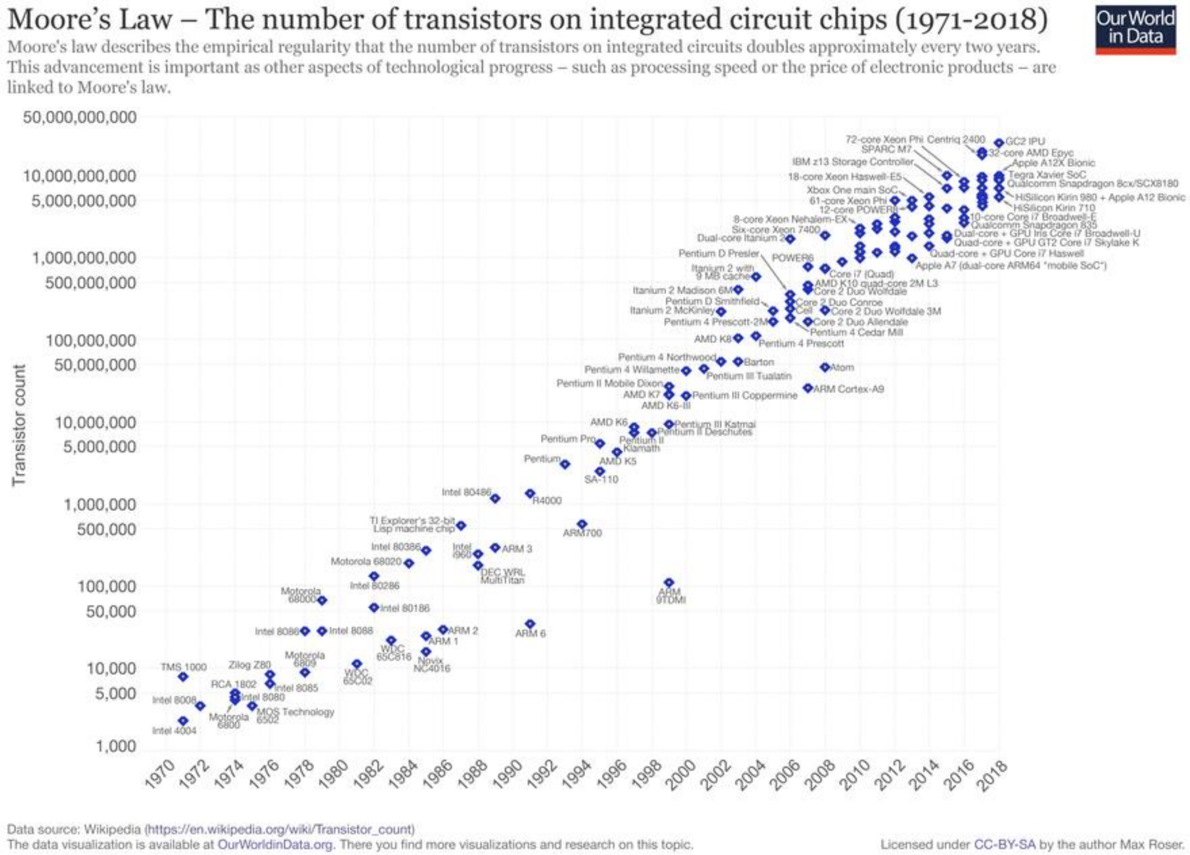
Early Computers



Plot of CPU transistor counts against dates of introduction. Note the logarithmic vertical scale; the line corresponds to exponential growth with transistor count doubling every two years.

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Personal Computers

- William Hewlett and David Packard (Stanford University) formed the prototype of the Hewlett-Packard (HP) company in the garage of Palo Alto (California) in 1938.
- HP was originally named Hewlett-Packard or Packard-Hewlett decided by throwing the copper plate.
- HP merged with PC giant Compaq in 2002

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Personal Computers

- 西元1964年
  - IBM推出了第一部以積體電路（IC，Integrated Circuit）為基礎元件的IBM 360型計算機
  - Douglas Engelbart發明了滑鼠（mouse），它之所以暱稱為滑鼠，乃是因為它的末端有著長長的尾巴。

– IBM introduced the PC (Altair 8800) in 1981.
  - Accepted by business
  - Became the standard hardware design for most desktop computers
  - Most PCs use software from Microsoft

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Personal Computers

- Steve Jobs and Steve Wozniak designed the Apple I in 1976 and Apple Computer established at the time.
- The first GUI OS was introduced in 1984.
- In 1985, Jobs resigned from Apple and established NeXT.
- In 1996, Apple acquired NeXT, and Jobs returned to Apple the following year, leading Apple to become a technology giant.

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Personal Computers

- Bill Gates and Paul Allen founded Microsoft in 1977.
- Initially, it mainly sold Altair 8800 and BASIC interpreter.
- MS DOS vs 86 DOS in 1980.
- GUI OS issue.
- Microsoft Windows operating system and Microsoft Office software.

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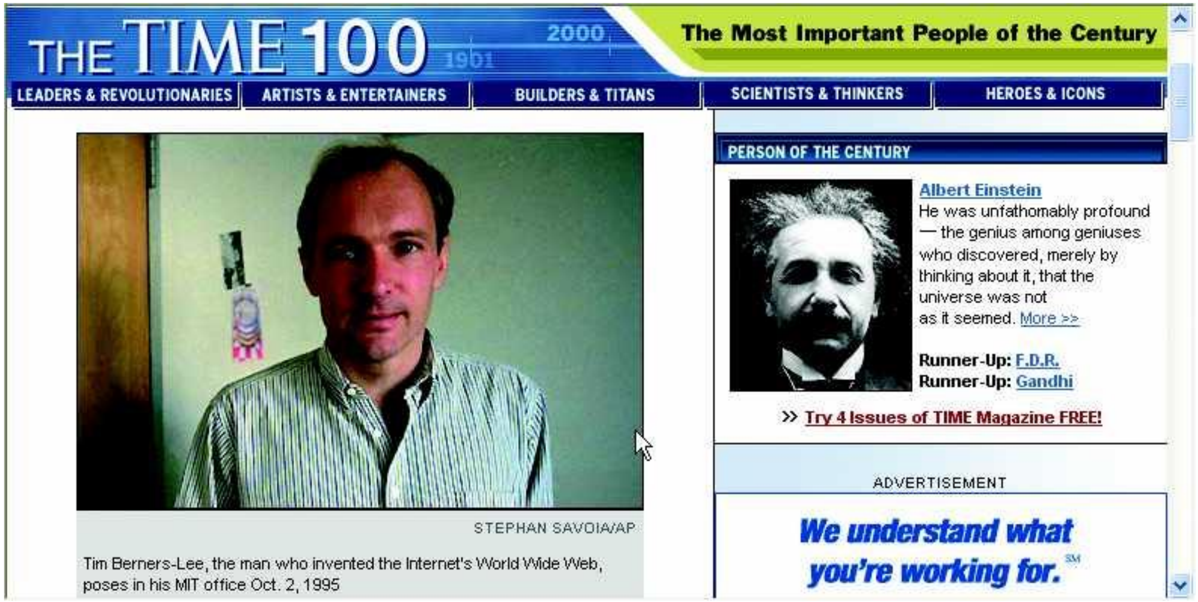
End of the 20th Century

- Internet revolutionized communications
  - World Wide Web in 1990.



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End of the 20th Century

- Internet revolutionized communications
  - Search Engines.
  - In 1998, Google was launched by Stanford PhD students Larry Page and Sergey Brin.

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End of the 20th Century

- Miniaturization of computing machines
  - Smartphones
  - iPhone (Apple), Android (Google) in 2007
  - Google enters mobile phone market, launches GPhone in 2008.

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End of the 20th Century

- Miniaturization of computing machines
  - Embedded (GPS, in automobile engines)
  - A system consisted of amounts of objects with ability of communication for specific goals.
  - In 1985 Peter T. Lewis proposed the term Internet of Things.
  - Bill Gates' Book of the Future in 1995 mentions that objects can be connected.
  - 温家宝 "感知中国" 2009.

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End of the 20^{th} Century

- Artificial Intelligence
- AlphaGo Zero beats then world champion Lee Sedol in the game of Go in 2017.
- IoT -> Cloud Computing -> Big Data -> Deep Learning -> AI.

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0.3 An Outline of Our Study

- Chapter 1: Data Storage
- Chapter 2: Data Manipulation
- Chapter 3: Operating Systems
- Chapter 4: Networks and the Internet
- Chapter 5: Algorithms
- Chapter 6: Programming Languages

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An Outline of Our Study (continued)

- Chapter 7: Software Engineering
- Chapter 8: Data Abstractions
- Chapter 9: Database Systems
- Chapter 10: Computer Graphics
- Chapter 11: Artificial Intelligence
- Chapter 12: Theory of Computation

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0.4 The Overarching Themes of Computer Science

- Computing technology is fundamental to being a part of the modern world
- This book will include applications and consequences of computer science
- Seven “Big Ideas” that unite computer science:
  - Algorithms, Abstraction, Creativity, Data, Programing, Internet and Impact

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Algorithms

- Computer Science is the science of algorithms
- Draws from other subjects, including
  - Mathematics
  - Engineering
  - Psychology
  - Business Administration
  - Linguistics

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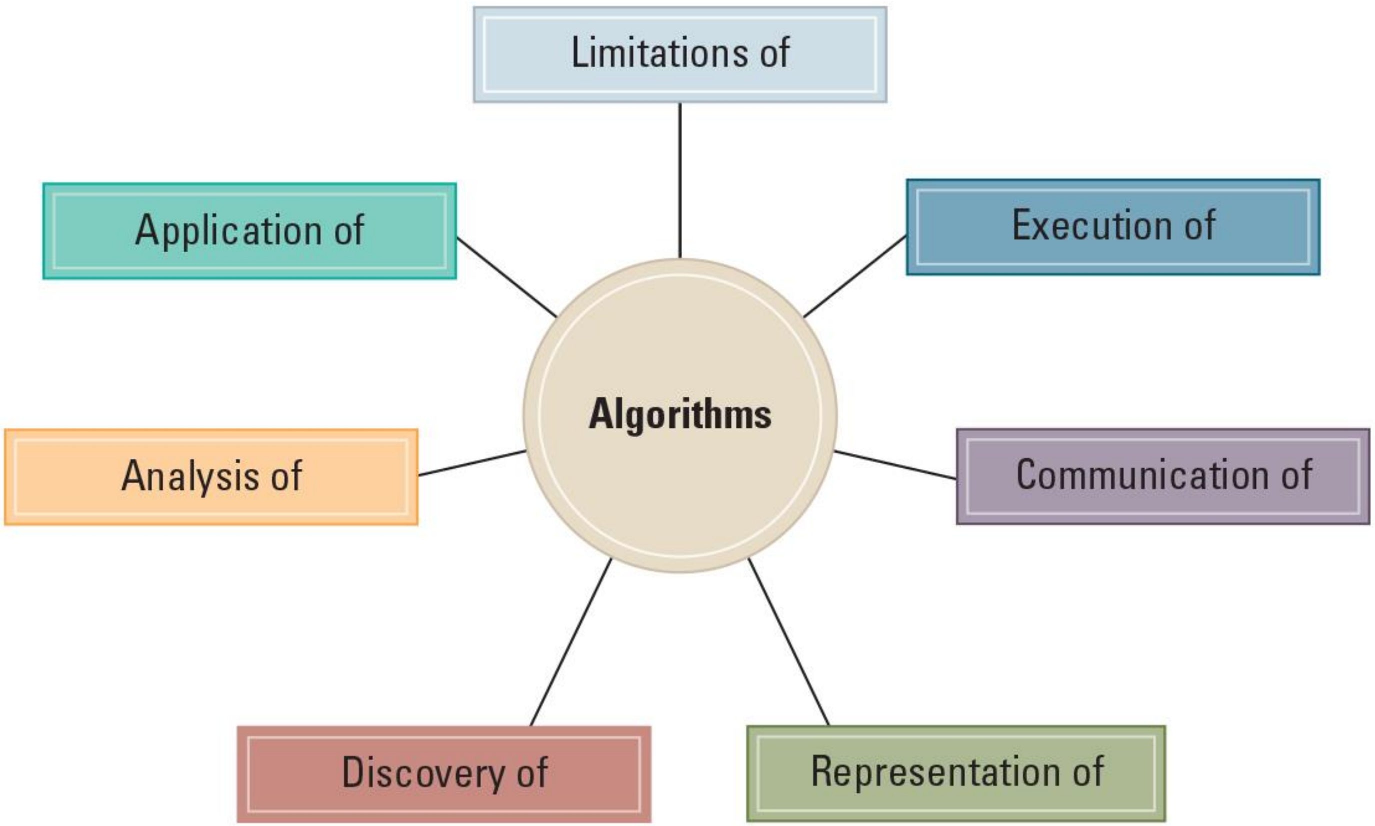
Figure 0.5
The central role of algorithms in computer science



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Given the Central Role of Algorithms

- Which problems can be solved by algorithmic processes?
- How can characteristics of different algorithms be analyzed and compared?
- How can algorithms be applied to produce intelligent behavior?
- How does the application of algorithms affect society?

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Abstraction

- **Abstraction:** The distinction between the external properties of an entity and the details of the entity's internal composition
- **Abstract tool:** A "component" that can be used without concern for the component's internal properties

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Creativity

- Computer science is inherently creative
  - Discovering and applying algorithms is a human activity
  - Extends existing forms of expression
  - Enables new modes of digital expression
- Creating large software systems is like conceiving a grand new sculpture

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Data

- Computers can represent any information that can be discretized and digitized
- Algorithms process and transform data
  - Search for patterns
  - Create simulations
  - Generate knowledge and insight
- Data is driving modern discovery

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Questions about Data

- How do computers store data about common digital artifacts?
  - Numbers, text, images, sounds, and video
- How do computers approximate data about analog artifacts in the real world?
- How do computers detect and prevent errors in data?
- What are the ramifications or an ever-growing and interconnected universe of digital data?

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Programming

- **Programming** is broadly referred to as:
  - Translating human intentions into executable algorithms
- Computer hardware is capable of only simple algorithmic steps
- Abstractions in a **programming language** allow humans to reason and encode solutions to complex problems

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Questions about Programming

- How are programs built?
- What kind of errors can occur in programs?
- How are errors in programs found and repaired?
- What are the effects of errors in modern programs?
- How are programs documented and evaluated?

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Internet

- Profound impact in the way information is:
  - Stored
  - Retrieved
  - Shared
- Privacy
- Security

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Impact

- Social, ethical, legal impacts including:
  - Security concerns
  - Issues of software ownership and liabilities
  - Social impact of database technology
  - Consequences of artificial intelligence

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Impact explored through “Social Issues” questions

- Social Issues questions are meant to increase awareness of:
  - Various stakeholders
  - Alternatives
  - Short term and long term consequences
- Character-based ethics
  - “Who do I want to be?”
  - Become more aware, insightful, and sensitive to the issues involved

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